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ABSTRACT

This study was prompted by the change in New York State certification (effective October 1968) which requires only 18 hours of courses in college mathematics for permanent certification in secondary school mathematics. The study does not suggest any recommendations as to the desired preparation for teaching secondary school mathematics, but information regarding current practices and recommendations from mathematicians and mathematics teachers is presented. (FL)

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Certification of Teachers of Secondary School Mathematics

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This study was occasioned by the change in New York State certification (effective October 1968) and the concern of the Association of Mathematics Teachers of New York State about the effects of the new regulations on the qualifications of future teachers of secondary school mathematics. The new regulations require only 18 hours of courses in college mathematics even for permanent certification, with no specification of content of the courses. The Bureau of Certification in New York State prepared a rationale for its decisions prior to the October 1968 date and since then many articles and communications have appeared on the subject of adequate subject matter preparation for teaching and also on the proper location of certification responsibilities. One of the most recent discussions is contained in the February 1970 issue of New York State Education, the journal of the New York State Teachers Association, in a special section entitled Certification at the Crossroads. After reading the several points of view presented one is convinced that the issues are still debatable and that final resolutions of the certification process are still in the future. Indeed one can foresee continual reviews of the process.

We do not offer, in this study, any firm recommendations as to the adequate preparation for teaching secondary school mathematics. We do present information and interpretation regarding present practices together with recommendations from mathematicians and teachers of mathematics. Financial support for the study was obtained from Institutional Funds of the State University of New York at Buffalo through the Research Foundation of the State University of New York during the 1969-70 academic year. Valuable assistance in collating and analyzing data was given by Mr. John Democko, graduate assistant in mathematics at the State University of New York at Buffalo.

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There were three phases in our study. In Phase I we requested information regarding current certification practices from all 50 states and from Puerto Rico and the District of Columbia. All but one state sent the requested information. Phase II involved those institutions of higher education in New York State which had programs in the preparation of secondary school teachers of mathematics and whose programs were approved by the State Education Department. Information was sought concerning: whether or not programs approved prior to October 1968 were being adhered to; what changes, if any, had been made in approved programs since October 1968; what, if any, changes in approved programs were presently contemplated. Phase III made use of a questionnaire sent to directors of 1970 NSF summer institutes in mathematics and to former institute participants in summer institutes at the State University of New York at Buffalo from 1960 to 1965. All these persons were asked to give recommendations as to minimal preparation in mathematics deemed necessary for teaching grades 7-8, 9-10, 11-12 and for teaching slow learners, average students and college-capable students within those grade levels. The results from each phase of the study follow with comments.

I.

It is appropriate to review the general CUPM recommendations for teaching secondary mathematics. The Committee states that a Bachelor's degree with a major in mathematics is desired together with a minor in a second subject. The second subject should be pursued in sufficient depth to develop an appreciation of the application of mathematics in that subject. The major in mathematics should include: three courses (semesters or terms) in analysis, two in modern algebra, two in geometry, two in probability and statistics (based on the calculus), one in computer science, and two in upper-class electives in mathematics. The inclusion of the language of logic and sets is assumed. Minimal preparation for different levels of teaching is also part of the CUPM recommendations. Four secondary school levels are identi-

fied: (1) grades K-6, (2) elements of algebra and geometry (normally grades 7-8), (3) high school mathematics 9-12, (4) elements of calculus, linear algebra, probability, etc. (12th grade).

As a rule, state certification requirements are divided into three categories: general education, professional education, and specialized education. Most states are agreed that prospective teachers in all subjects should have a bachelor's degree with a distribution of hours in general education (English, language, history, etc.) and a certain number of hours in professional education (educational psychology, methods of teaching, student teaching, etc.). It is the category of specialized education that is the concern of this study.

There are also three basic types of certification: temporary or provisional, standard and professional. The standard certification usually requires some teaching experience and evidence of professional growth or study beyond the bachelor's degree. The professional certificate requires, in most cases, a master's degree or its equivalent and teaching experience and is sometimes called a permanent certificate.

Some states take the viewpoint that the preparing institution should decide the specific requirements for teacher preparation. The institution, then, is given maximum freedom in setting up its program but final approval of the program is a state function. Certification by the state is automatic when a student is recommended by an institution with an approved program. The state, it must be emphasized, sets no minimum number of required hours in specialized education that every institution has to meet and no specific courses in mathematics are demanded. Out of state applicants become special cases. We label states operating in this manner "approved program states" in that they require that the applicant's program must be approved either by the state or the preparing institution or both. Such "approved program states" are Alabama, Colorado, Hawaii, Iowa, Kentucky, Nebraska, Nevada, New Mexico, North Carolina, North Dakota, South Dakota, Vermont, Washington, Wisconsin, New Jersey, Pennsylvania (and also Puerto Rico).

Another approach to certification is for a state to require a minimum number of hours in mathematics together with certain required courses or else a certain proportion of upper-level courses in the total minimum. The specific course recommendations reflect, in many cases, those of CUPM. For states operating in this manner we present the chart found on the next page. Please note that all "hours" have been reduced to "semester hours". Requirements are for a beginning teacher.

(see chart next page)

The last type of approach to certification is to specify a minimal number of hours in mathematics, with no particular course demands. The following states fall into this category, requirements again being those for a beginning teacher:

Arizona	18 hours required
Connecticut	18
Florida	21
Illinois	20
Louisiana	12
Maine	30
Maryland	24
Michigan	30 hour major
Montana	30 hour major
New York	18
Rhode Island	18

(Pending approval)

Washington, D.C.	30 for Junior High, Master's for Senior High.

Several states indicated that present certification practices were being evaluated and that changes may be under consideration. There was no indication of the direction of contemplated changes, however. A review of the preceding

	Minimum hours	Analytic Geometry and Calculus	Abstract Algebra	College Geometry	Probability and Statistics	Computer Science	Electives at or above level of coll. alg.	Upper class Electives	College Algebra and Trigonometry	Graduate Level Credit
Arkansas	24	6	6	3			9			
California (1)								15		6
Delaware (2)	30	12					30			
Florida	21	3								
Georgia	23 1/3	3 1/3	3 1/3	3 1/3						
Idaho (major)	30		3	3					3	
Idaho (minor)	20		3	3					3	
Indiana (major)	40	12	3	3	3			3	4	
Indiana (minor)	24	12	3	3				2	4	
Kansas	18	3						15		
Minnesota (major)	26	9	6	3	3			5		
Minnesota (minor)	18	6						6		
Mississippi	24	6						9	6	
Missouri	30	3						10		
Ohio	18						3		6	
Oklahoma	28						21			
Oregon	24	3	3	3						
South Carolina	18	3								
Tennessee	18	3							3	
Texas	24							12		
Utah (major)	26 2/3									
Utah (minor)	14 2/3							50 %		
Virginia	27	3								
West Virginia	30	12	3	3				6	6	
Wyoming	24	3	3	3				3		

(Upper Class Electives means at or above calculus)

(1) California defines upper class electives as those open only to juniors, or above.
(2) The figure (12) is required for 9-12 calculus added certificate.

analysis discloses an amazing spread of requirements from a 12 hour minimum to a 40 hour minimum in mathematics courses. In only one or two states could one say that CUPM recommendations have been adopted.

II.

In the second phase of this study questionnaires were sent to 90 colleges and universities in New York State which were thought to have teacher preparation programs. Information about present programs was sought, particularly with respect to changes or contemplated changes in programs registered with the State Education Department, in the light of the requirements in effect October 1968. Fifty-five institutions replied. They could be placed, generally, in three categories:

1. Those who answered "Yes, we are adhering to our program registered prior to October 1968 and contemplate no significant changes". None of these institutions, numbering 19, sent copies of their registered programs.
2. Those who answered "Yes, we are adhering to our registered program" and who sent copies of their programs explaining minor changes and contemplated future change. There were 22 such institutions.
3. Those who answered "No, we are not adhering to our program registered prior to October 1968". They described the changes which had been made. There were 10 of these institutions.
4. Institutions which had only elementary programs and/or no secondary programs.

In category 1 we placed

Adelphi
Colgate
Columbia University, Teachers College
Hamilton
Hartwick
Hobart and William Smith
King's
Long Island University, Southampton College
LeMoyne
Manhattanville
Molloy Catholic College for Women
Roberts Wesleyan
University of Rochester, College of Education
Siena
Vassar
Wagner
SUNY at Buffalo
SUC at Cortland
St. Joseph's College for Women

While no significant changes were contemplated by the above institutions, a half-dozen indicated some study under way but foresaw only routine changes such as updating courses and introducing additional electives.

The 22 institutions in category 2 sent copies of their registered programs and also explained any recent or contemplated changes. It is important to record that not one of the 22 was considering a reduction in the required minimum number of hours in mathematics in the light of the reduced state certification requirements to teach secondary mathematics.

The 10 institutions who replied that they were not adhering to their previously registered programs gave information regarding changes made and reasons

for the changes. Only two in this category 3 made the state changes a basis for their own changes or for their new programs. Some have actually increased requirements in mathematics. One is contemplating the requirement of a major in mathematics for all prospective secondary teachers of mathematics. Others are updating and improving their programs.

Information obtained from institutions placed in categories 2 and 3 has been used here to compare present or planned programs with the CUPM recommendations for beginning teachers. A rather subjective rating has been given to 30 of the 32 programs (total of categories 2 and 3) by assigning grades A, B, C. (Two of those in categories 2 and 3 are not included for lack of appropriate information.) A means that a program meets CUPM recommendations. B means that a major in mathematics is demanded including at least 30 hours of mathematics excluding low-level courses such as business mathematics. The 30 hours includes a 9-16 hour calculus sequence, linear and abstract algebra, geometry and upper-class electives such as probability-statistics, topology, more analysis, foundations in mathematics, computer mathematics. A rating of C is given to programs considered minimal, i.e., falling short of a B rating in varying degrees such as by reason of a small number of hours in mathematics and/or lack of specific course demands. Pluses and minuses have also been used on ratings. On the basis of information available for this analysis, the ratings follow:

Category 2	Hunter College, CUNY	C
	Queens College, CUNY	B-
	Iona College	C+
	Ithaca College	A-
	Keuka College	C
	Long Island U, CW Post College	C+
	Manhattan College	B
	Marymount College	C
	Mt. St. Mary College	B-
	Nazareth College of Rochester	A-
	Pace College	B
	Pace College (Math and Science, Math only rated)	C
	Russell Sage College	B-
	Skidmore College	B-
	St. John Fisher College	C
	The College of St. Rose	C
	Syracuse University	C+
	SUNY College at Brockport	C+
	SUNY College at Fredonia	A-
	SUNY College at New Paltz	B
	SUNY College at Potsdam	C
Category 3	Canisius College	B-
	Good Counsel College	A-
	College of Mt. St. Vincent	C
	Niagara University	B
	Rosary Hill College	A-
	St. Lawrence College	C
	SUNY College at Buffalo	B
	SUNY College at Oswego	C
	SUNY at Stony Brook	C

The rating indicates that some institutions in New York State are almost meeting the CUPM recommendations while many of them are meeting the "prior to October 1968" requirements of the State Education Department. Moreover, practically none is reducing requirements to the October 1968 level.

III

Information from two sets of persons was sought in the final phase of our study. The same questionnaire was sent to all persons, however. What we sought was opinions regarding minimal subject matter knowledge needed to teach at three grade levels and to teach three types of students at each grade level. The two sets of people from whom opinions were solicited were professors of mathematics and secondary school teachers. We used the listing of directors of 1970 NSF summer mathematics institute directors to reach college professors under the assumption that they would be especially interested in teacher education. The secondary teachers selected for solicitation were former institute participants at the State University of New York at Buffalo during a five-year span in the early 1960's. Additional opinions came from members at the 1969-70 AYI institute at Pennsylvania State University due to the interest of Dr. Frank Kocher who sent the additional information back with his own completed questionnaire. The replies of his students were incorporated with those of our former instituters.

The number of replies to our questionnaires was not as large as hoped for, but certain patterns of thinking did emerge. We had 46 replies from professors of mathematics and 59 replies from teachers. Interpretation of the replies was difficult in many respects. Many respondents wrote comments rather than filling out the 3 x 3 matrix (3 grade levels, 3 types of students). Many replies gave only one set (rather than 9) of requirements with the remark that teachers are not generally hired for specific grade levels or types of students. Our grade levels were 7-8, 9-10, 11-12 and within each grade level we placed

the three types "slower students", "average students", "college-capable students".

The chart reveals the wide variety of recommendations from the respondents. One gratifying result appears - the recommended preparation for teaching the slower students is not too much weaker than that recommended for teaching the other two types. Twenty persons recognized the need for a special methods course for teaching the slower students in grades 7 and 8. It was surprising that not more persons specified a major in mathematics as necessary, but perhaps the specific course recommendations imply a major in many more cases. There is strong support for at least one course in calculus, upper-level geometry, modern algebra, and probability-statistics with courses in geometry receiving the most enthusiastic support. Computer science (programming) received support although not as much as expected. Number theory and history of mathematics had considerable support also as well as logic and sets. Topology was recommended by several persons especially for college-capable students. A reflection of modern trends is the seldom-mentioned course in "theory of equations".

Recommendations from Directors of Institutes and Former Institute Participants

Specific recommendations	Type 1 (Slower Students)										Type 2 (Average Students)										Type 3 (College-capable Students)									
	Total for Type 1	7-8			9-10			11-12			Total for Type 2	7-8			9-10			11-12			Total for Type 3	7-8			9-10			11-12		
		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T
Major in Math.	20	11	2	13	1	5	6	1	0	1	25	10	3	13	2	8	10	1	1	2	22	11	4	15	0	5	5	1	1	2
Minor in Math.	11	3	7	10	1	0	1	0	0	0	11	2	9	11	0	0	0	0	0	0	10	5	4	9	1	0	1	0	0	0
Master's degree	4	0	0	0	1	0	1	2	1	3	7	0	0	0	1	0	1	2	4	6	7	0	0	0	1	0	1	2	4	6
College Algebra	22	12	5	17	2	0	2	2	1	3	20	13	5	18	1	0	1	1	0	1	19	14	3	17	1	0	1	1	0	1
Trigonometry	18	7	3	10	5	0	5	2	1	3	16	8	3	11	3	0	3	2	0	2	17	8	3	11	4	0	4	2	0	2
Structure of Real Number sys. (theory of arith.)	15	5	9	14	1	0	1	0	0	0	16	5	10	15	1	0	1	0	0	0	15	5	10	15	0	0	0	0	0	0
Calculus I (incl. anal. geometry)	17	18	23	41	10	2	12	2	2	4	72	21	23	44	13	5	18	4	6	10	70	26	22	48	9	5	14	4	4	8
Calculus II	49	17	17	34	6	4	10	3	2	5	68	21	20	41	9	8	17	4	6	10	57	20	17	37	7	6	13	4	3	7
Calculus III	19	7	8	15	1	1	2	0	2	2	28	6	9	15	3	6	9	2	2	4	31	6	9	15	6	6	12	2	2	4
Calculus IV	13	4	5	9	1	1	2	0	2	2	14	4	5	9	1	2	3	1	1	2	16	3	3	6	1	5	6	2	2	4
Differential Equations	6	0	0	0	0	0	0	3	3	6	9	1	1	2	1	1	2	3	2	5	15	2	1	3	2	2	4	6	2	8
Advanced Calculus (and real variables)	12	1	0	1	0	0	0	6	5	11	25	1	1	2	4	1	5	9	9	18	48	1	0	1	2	2	4	21	22	43
Geometry (coll., mod.)	66	19	24	43	8	8	16	5	2	7	78	22	25	47	14	11	25	4	2	6	81	25	27	52	15	9	24	3	2	5
More Geometry	11	0	0	0	2	6	8	0	3	3	20	0	0	0	3	10	13	0	7	7	17	0	0	0	2	7	9	2	6	8

Key: I = Former institute participants

D = Institute directors

T = Total

see next page

	Type 1 (Slower Students)										Type 2 (Average Students)										Type 3 (College-capable Students)									
	Total for Type 1	7-8			9-12			11-12			Total for Type 2	7-8			9-10			11-12			Total for Type 3	7-8			9-10			11-12		
		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T
Algebra (abst., mod.)	61	17	22	39	5	11	16	4	2	6	72	24	25	49	6	11	17	3	3	6	75	24	28	52	7	10	17	4	2	6
Linear Algebra	30	1	7	8	6	12	18	2	2	4	46	3	8	11	6	16	22	6	7	13	58	4	11	15	11	16	27	7	9	16
More Algebra (abstract)	3	0	0	0	0	0	0	1	2	3	10	1	1	2	2	1	3	0	5	5	8	0	0	0	1	1	2	3	3	6
Probability-statistics	41	11	10	21	5	5	10	6	4	10	59	13	11	24	9	6	15	13	7	20	66	11	14	25	11	6	17	14	10	24
Computer (pgr. science)	23	3	6	9	5	2	7	3	4	7	35	6	6	12	6	4	10	5	8	13	43	6	6	12	5	6	11	9	11	20
Sets and Logic	19	9	4	13	1	0	1	3	2	5	25	11	5	16	4	2	6	2	1	3	26	9	8	17	4	1	5	4	0	4
History of Math.	21	8	6	14	1	1	2	1	4	5	26	9	5	14	2	1	3	4	5	9	25	10	5	15	0	1	1	4	5	9
Foundations of Math.	10	2	7	9	0	0	0	1	0	1	13	1	8	7	2	0	2	1	1	2	14	2	8	10	2	1	3	1	0	1
Finite Math.	9	2	5	7	0	0	0	2	0	2	9	2	4	6	1	0	1	1	1	2	10	3	4	7	2	0	2	0	1	1
Number Theory	22	5	5	10	2	4	6	2	4	6	26	8	6	14	2	4	6	3	3	6	20	7	7	14	4	3	7	2	4	6
Theory of Equations	3	0	1	1	1	0	1	1	0	1	6	1	1	2	3	1	4	0	0	0	8	1	1	2	4	1	5	0	1	1
Numerical Analysis	1	0	1	1	0	0	0	0	0	0	2	0	1	1	0	0	0	0	1	1	8	0	1	1	0	1	1	3	3	6
Topology	9	0	0	0	1	0	1	4	4	8	12	1	1	2	3	0	3	3	4	7	19	1	0	1	3	1	4	7	7	14
Complex Variables	3	0	0	0	0	0	0	0	3	3	7	0	0	0	0	0	0	3	4	7	12	0	0	0	0	0	0	6	6	12
Applied Math.	6	2	1	3	2	0	2	0	1	1	4	1	1	2	0	0	0	1	1	2	4	2	1	3	0	0	0	0	1	1
Business Math.	6	1	1	2	4	0	4	0	0	0	4	1	1	2	1	0	1	1	0	1	----------									
Methods (teaching secondary mathematics)	12	10	0	10	2	0	2	0	0	0	13	8	0	8	3	0	3	1	1	2	10	9	0	9	1	0	1	0	0	0
Special methods (slow students)	20	10	6	16	1	2	3	1	0	1	----------										----------									
Math Recreations	2	1	0	1	0	0	0	1	0	1	1	0	0	0	1	0	1	0	0	0	----------									
Drafting	3	0	0	0	1	0	1	2	0	2	2	2	1	0	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0

	Type 1 (Slower Students)										Type 2 (Average Students)										Type 3 (College-capable Students)									
	Total for Type 1	7-8			9-10			11-12			Total for Type 2	7-8			9-10			11-12			Total for Type 3	7-8			9-10			11-12		
		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T		I	D	T	I	D	T	I	D	T
Physics	2	0	0	0	2	0	2	0	0	0	3	1	0	1	2	0	2	0	0	0	4	1	0	1	2	0	2	1	0	1
Chemistry	1	0	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	0	0	0	1	1	0	1	0	0	0	0	0	0
Curriculum Instruction	2	0	1	1	0	0	0	1	0	1	1	1	0	1	1	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0
Work Experience	1	0	0	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	0	1	----------									

If one were to extract from our questionnaire replies a "most recommended" program for teacher preparation in mathematics, regardless of grade level or type of student to be taught, it might be:

A calculus sequence from analytic geometry to advanced calculus, including an introduction to real variable theory	12 - 15 hours
A course in abstract algebra, including basic algebraic structures	3 - 6 hours
A course in college geometry, including some non-euclidean geometries	3 - 6 hours
A course in probability-statistics using calculus	3 - 6 hours
A course in computer science including programming	3 hours
Electives from algebra, geometry, number theory, topology, history of mathematics, foundations of mathematics, real or complex variables	9 - 12 hours
Total	33 - 48 hours

The above program does not mention sets and logic specifically, it being assumed that the needed concepts would be used throughout the program.

General observations.

If the CUPM recommendations are taken as a standard and a desired goal, this study reveals that certification requirements set up by states are far short of that standard. No attempt was made to determine any trends in state requirements although we did invite comments from state officials. No

data was given us to indicate whether requirements had been weakened or strengthened in the last few years as far as hours of study in mathematics was involved.

The institutions of higher education in New York State seem to be examining their programs and if any trends are indicated they appear to be in the direction of greater depth and breadth in mathematics background. Very few schools, however, have yet completely met the CUPM recommendations. On the other hand, the latest New York State certification requirements have not been reflected in any changes of note in the teacher education programs in the institutions which have programs registered in the State Education Department.

Directors of NSF institutes and institute participants, judging from our respondents, would recommend many of the same courses for prospective teachers as does CUPM. This would be expected from the directors and is probably not surprising from instituters. Opinions from teachers who had not attended institutes might be quite different.

The question of how much subject matter background a teacher needs to be a "good" teacher is often raised, but has never been satisfactorily answered. This study has avoided the question, but was based on the assumption that some knowledge of mathematics is one of the prerequisites for successful teaching of mathematics. We have also avoided the question of who should perform the certification function except to indicate that the question is much in the minds of all concerned - teachers, administrators and state officials, as well as professional groups. It is important that the topic of certification be kept before all those concerned.

April 1970

State University of New York at Buffalo